ROBOTICS 12 COURSE
AT YALE SECONDARY SCHOOL
BAA APPLICATION

DERECK DIROM

PREAMBLE FROM CARNEGIE MELLON UNIVERSITY

RATIONAL: WHY ROBOTICS/STEM EDUCATION

We can't predict what the hot new technology will be in five years, but we can confidently predict that it will include computer programming, electronic embedded systems, engineering design, and mathematics. If you believe these things, then you need to know that robotics has the ability to teach these concepts. At the same time, robotics teaches 21st century skill sets like time management, resource allocation, teamwork, problem solving, and communications.

Think about this...

- Approximately 98% of all the 32-bit microprocessors currently in use worldwide are used in embedded systems; in other words they are being used in robotic smart technologies.
- By the year 2010, it is forecasted that 90% of the overall program code developed will be for embedded computing systems; to innovate and compete globally we will need more people that know how to program.
- Robotics Technology is a hundred billion dollar emerging industry that has moved from being an industry that could potentially employ thousands of people to an *integral part of all industries*. Robotics will impact the economy the same way that mass production impacted the industrial revolution and the computer impacted the information age.
- Science and Engineering (S&E) occupations are projected to grow by 26% from 2010 to 2020, twice as fast as the overall job market during that period (S&EI 2008) yet we have fewer students pursuing S&E careers.
  - Carnegie Mellon University – Robotics Academy 2009

THE TEACHING ROBOTC FOR TETRIX CURRICULUM

This curriculum is designed for a teacher with no programming background that is interested in teaching programming and engineering. This curriculum also supports a teacher that knows how to program, but has students of various skill levels and wants to allow them to move at their own pace. The teaching materials utilize a high level of multimedia and have been tested with hundreds of students; they work. ROBOTC is the best programming software available for use with TETRIX and the NXT if you consider the percentage of teams that use ROBOTC software and made it to the finals of the FTC competition.

Math is the language of science, engineering and technology

Many teachers see robotics as a way to teach STEM education. We've seen that robotics *does* provide unique opportunities for teachers to place engineering design, scientific process, technological literacy and mathematics in contexts that students find engaging and understand. Across the nation, many schools and community-based organizations are using robotics to address STEM competencies.

BAA Robotics 12 Framework

District Name: Abbotsford

District Number: 34

Developed by: Dereck Dirom

Date Developed: September 2009

School Name: Yale Secondary School

Principal's Name: Glen Roger

Board/Authority Approval Date:

Board/Authority Signature:

Course Name: Robotics 12

Grade Level of Course: 11 or 12

Number of Course Credits: 4

Number of Hours of Instruction: 120

Prerequisite(s): C+ in Math 11, C+ in either Physics 11, Biology 11 or Chemistry 11

Special Training, Facilities or Equipment Required: 10 laptop computers, 10 NXT Lab Kits, TETRIX Lab Kits, NXT-G 2.0, RobotC, 10 lab tables, adequate electrical outlets, training in lab equipment.

Description of ROBOTC: ROBOTC is a powerful C-based programming language with a Windows environment for writing and debugging programs, and the only programming language at this level that offers a comprehensive, real-time debugger. ROBOTC is a cross-platform solution that allows students to learn the type of C-based programming used in advanced education and professional applications.

Course Synopsis: This course uses NXT and TETRIX sensors, motors, gears and microcontroller units programmed in NXT-G and ROBOTC to construct autonomous wheeled mobile robots. The course contains structured laboratory exercises in NXT and TETRIX mechanics, software design, sensor and motor principles, and feedback control. Time is spent designing mobile robots that will compete in several robotic competitions. The lectures will focus on effective engineering techniques using the appropriate motors, sensors, and control features to complete the assigned tasks.

Rationale: In recent years, robotic modular systems have greatly reduced the technical skill required to build simple and complex robotic devices. Mechatronic Engineering courses (often project-based) are now offered to undergraduates as well as to graduate students at all major Universities in North America. Offering such a course to high school students as part of our science programs could:

1. Appeal to students interested in mechatronics (engineering robotic systems and programming) and art
2. Explore, in a hands-on way, connections between science, math, technology and aspects of engineering and art;
3. Introduce problems in artificial intelligence such as control or pattern recognition

This would allow students to:

1. To learn about integrated system design that includes mechanical, electrical, and computational components
2. To study the mechanical mechanisms necessary for robot movement and actions.
3. To study the electrical mechanisms of sensor sampling and signal processing.
4. To study the computational mechanisms of autonomous robotics including
5. To study the computational mechanisms necessary for sensory perception.
6. To provide a hands-on experience to practical robotics.
7. To learn to work in a cross-functional team with people from different disciplines
8. To learn about group dynamics and teamwork
9. To learn about possible post secondary options / career options

Unit Number	Description	Approximate Hours
1	Introduction to Robotics	1.5
2	Engineering Fundamentals	7.5
3	Introduction to the NXT Hardware	3
4	NXT Lab Setup	3
5	NXT Movement / Backwards / Turning Lab Setup	7.5
6	NXT Sensing	21
7	NXT Variable and Functions	21
8	NXT Remote Control	3
9	Introduction to TETRIX Hardware	9
10	TETRIX Lab Setup	6
11	NXT / TETRIX Engineering Solutions	7.5
12	NXT / TETRIX Engineering Challenges	30
	TOTAL	**120 Hours**

UNIT ONE: Introduction to Robotics **Time: 1.5 hours**

The introduction to robotics unit introduces students to the overall goals of the course and the basic timeline of events. It also introduces the students to the engineering, programming and robotics systems used in the course.

Curriculum Organizers: Course Overview

It is expected that students will:

- Describe the goals of the course.
- Define what an autonomous / IR robot is.
- Define what the engineering process looks like.
- Define what a program is.
- Identify the different platforms used in the course.

UNIT TWO: Engineering Fundamentals **Time: 7.5 hours**

The fundamental unit introduces students to safety, project management, programming basics, and the hardware used in both the NXT and TERTRIX robotic systems.

Curriculum Organizers: Safety Protocols

It is expected that students will:

- Demonstrate proper safety protocols (safety is an attitude and is valued across all industries).
- Identify the proper lab safety rules.
- Demonstrate how to complete a safety checklist.
- Demonstrate an awareness of general electrical / power tools safety.

Curriculum Organizers: Lab Logistics

It is expected that students will:

- Describe the rules / expectations for using the computer.
- Explain the robotic hardware rule and expectations.
- Demonstrate the appropriate lab setup and cleanup procedures.

Curriculum Organizers: Project Management

It is expected that students will:

- Demonstrate effective Engineering journal techniques.
- Apply the appropriate project management practices (the Engineering Process) to solve problems.
- Demonstrate how to develop an organizational matrix of ideas.
- Demonstrate how to develop a Gantt chart of a PERT chart.

Curriculum Organizers: Introduction to ROBOTC Programming

It is expected that students will:

- Explain basic robotic behaviour.
- Identify the basic ROBOTC interface and programming environment.
- Explain the importance of constructing flowcharts and Pseudocodes.
- Demonstrate basic programming syntax, concepts and rules (comments, reserved words and role of whitespace).
- Identify and explain the basic parts and functions of the robotic hardware devices.

UNIT THREE: Introduction to the NXT Hardware **Time: 3 hours**

The NXT platform consists of a microprocessor unit, a set of sensors, and a variety of extra TECHNIC part for constructing a basic robotic device.

Curriculum Organizers: NXT Hardware Overview

It is expected that students will:

- Explain the purpose and logistical layout of the NXT lab kit.
- Identify the various parts and their potential use (sensors and motors).
- Demonstrate an ability to use electronic reference materials provided to assist in the engineering process.

UNIT FOUR: NXT Lab Setup **Time: 3 hours**

Student will get an overview and instructions on how to build the basic REM Robotic device, downloading the firmware and step to take to download and run a basic program.

Curriculum Organizers: NXT Lab Setup

It is expected that students will:

- Build the NXT REM robotic device.
- Demonstrate the appropriate technique and procedures for downloading the ROBOTC firmware.
- Demonstrate the appropriate technique and procedures for downloading a sample program.

UNIT FIVE: NXT Movement/Backwards/Turning **Time: 7.5 hours**

Student will learn the basic engineering and programming to make their robotic device move forward and backwards in any given direction. In addition to moving, students will learn how to make their robot to move a set distance and turn an exact degree in any give location.

Curriculum Organizers: Moving and Turning

It is expected that students will:

- Demonstrate the appropriate programming skills to have a robot move forward and backwards.
- Demonstrate the appropriate programming skills to modify the robots behaviour in terms of speed and direction traveled.
- Demonstrate the appropriate programming skills to have a robot travel forward/backward and turn in any direction.
- Demonstrate an ability to synchronize motor commands.
- Complete the MAZE Challenge.

UNIT SIX: NXT Sensing

Time: 21 hours

Student will learn the basic engineering and programming skills needed to use touch, ultrasonic, light, and sound sensors to create an autonomous robotic device.

Curriculum Organizers: Touch Sensor

It is expected that students will:

- Build a touch sensor attachment for the REM.
- Explain the purpose and programming requirements of Loops.
- Demonstrate an ability to create a Sense-Plan-Act Algorithm.
- Demonstrate an ability to use Boolean Logic for building syntax.
- Complete the TOUCH SENSOR Programming Challenges.

Curriculum Organizers: Ultrasonic Sensor

It is expected that students will:

- Build an ultrasonic sensor attachment for the REM.
- Apply the formula to calculate a Threshold for the ultrasonic sensor.
- Explain the role of Random Numbers in building syntax.
- Demonstrate an ability to use Boolean Logic in building syntax.
- Complete the ULTRASONIC SENSOR Programming Challenges.

Curriculum Organizers: Rotation / Degree Sensor

It is expected that students will:

- Apply the formula to determine the circumference of a wheel and convert it into degree to program a robot to travel an exact distance forward or backwards.
- Demonstrate an ability to program the robot to travel an exact distance accurately.
- Complete MEASURED DISTANCE / DEGREE TURN Challenge

Curriculum Organizers: Light Sensor

It is expected that students will:

- Build a light sensor attachment for the REM.
- Apply the formula to calculate a Threshold for the light sensor.
- Demonstrate an ability to program the robot to travel forward to a dark line and stop.
- Explain the role of If-Else Statements in creating syntax.
- Describe the role of Switch Case Statements in creating syntax.
- Complete the LIGHT SENSOR Programming Challenges.

Curriculum Organizers: Sound Sensor

It is expected that students will:

- Build a sound sensor attachment for the REM.
- Apply the formula to calculate a Threshold for the sound sensor.
- Demonstrate an ability to program the robot to react to sound and sound intensity.
- Complete the SOUND SENSOR Programming Challenge.

UNIT SEVEN: NXT Variables and Functions **Time: 21 hours**

Student will learn that complex tasks and environments require their robot to keep track of more than just what it can see at a given moment. Storing information, and performing calculations with the data allows your robot to be more independent and aware of its overall environment.

Curriculum Organizers: Automatic Thresholds

It is expected that students will:

- Explain the purpose and programming requirements of establishing the proper protocols for automatic Threshold calculations.
- Demonstrate the ability to determine the appropriate programming Values and Variables.
- Identify the proper method to debugging and problem solving programming errors.
- Demonstrate the correct method for programming the microprocessor to show text on the screen for feedback and reference.
- Complete the AUTOMATIC CALCULATIONS Programming Challenges.

Curriculum Organizers: Line Counting

It is expected that students will:

- Demonstrate the ability to determine the appropriate programming Threshold values.
- Identify the proper method to building a program that will count the required number of lines.
- Identify the proper method to debugging and problem solving programming errors.
- Complete the LINE COUNTING Programming Challenges.

Curriculum Organizers: Variables and Functions / Patterns of Behaviour

It is expected that students will:

- Explain the purpose and programming requirements of a Behaviour.
- Demonstrate the ability to create and using Functions.
- Determining the appropriate variables for programming syntax.
- Complete the FUNCTIONS Programming Challenges.

UNIT EIGHT: NXT Remote Control **Time: 3 hours**

Student will learn the basics of setting up a joystick controller to control the robot and assign behaviour to specific buttons.

Curriculum Organizers: How Remote Control Communication Works

It is expected that students will:

- Determine when joystick controls are necessary.
- Demonstrate the ability to build and program a robot and joystick control device.
- Complete the REMOTE CONTROL Programming Challenges.

UNIT NINE: Introduction to the TETRIX Hardware **Time: 9 hours**

Students will learn that the TETRIX platform consists of various structures, metal motors, servos, pivots, and electronic connections and wires.

Curriculum Organizers: TETRIX Hardware Overview

It is expected that students will:

- Explain the purpose and logistical layout of the TETRIX lab kit.
- Identify the various parts and their potential use (sensors and motors).
- Identify the various structures, components of the TETRIX kits.
- Identify what resource to use when building grippers and actuators.
- Determine the best technique for integrating the NXT and TERTIX components together.
- Identify the purpose and possible use of lab hand tools when constructing a robotic device.
- Demonstrate the ability to use electronic reference materials provided to assist in the engineering process.

UNIT TEN: TETRIX Lab Setup **Time: 6 hours**

Student will get an overview and instructions on how to integrate the NXT controller to the TETRIX motor controller, TETRIX servo controller and building a TETRIX Testbed.

Curriculum Organizers: TETRIX Lab Setup

It is expected that students will:

- Explain the basic design of a TETRIX Testbed.
- Build and test a TETRIX Testbed.
- Build and test a Mantis Robotic device.

UNIT ELEVEN: NXT / TETRIX Integration **Time: 7.5 hours**

Student will get an opportunity to engineer a combined NXT and TETRIX robotic device.

Curriculum Organizers: Combining Movement / Sensing

It is expected that students will:

- Build and test a mixed platform Robotic device.

UNIT TWELVE: NXT / TETRIX Challenges **Time: 30 hours**

Student will get an opportunity to engineer a combined NXT and TETRIX robotic device to complete two challenges.

Curriculum Organizers: Combining Movement / Sensing

It is expected that students will:

- Build and program a robotic device to complete the following challenges:
  1. Robot Mining Challenge.
  2. Robot Mine Removal Challenge.

INSTRUCTIONAL COMPONENTS:

One of the main instructional philosophies of robotics is that all students will experience success. Working within groups ensures that engineering teams can achieve success while supporting each other in the process. The final outcome of a robotics competition is only one part of the assessment. Some of the instructional strategies used in this course are:

- Peer teaching, just-in-time teaching mini lessons, demonstrations, multimedia modules, engineering teams, project based learning, scaffolding of knowledge, guided discovery, and self paced learning, engineering journals (goal setting / problems solving), and learning through observation.

SUMMATIVE ASSESSMENT COMPONENTS:

Summative assessment for the course will comprise the following unit challenges:

- **Unit Challenges = 70%:** Maze challenge, Touch Sensor challenge, Ultrasonic Sensor challenge, Light Sensor challenge, Sound Sensor Challenge, Measured Distance / Degree Turns challenge, Automatic Calculations Programming challenge, Line Counting Challenge, Functions Programming challenge, Remote Control Programming challenge
- **Final Course Challenges = 30%:** Robot Mining challenge, Robot Mine Removal challenge

PROJECT MANAGEMENT RESOURCES:

Students will learn that it does not matter what career they choose, it will be important to be able to manage projects and apply engineering processes to solve problems. The following resources will be used to assist students in organizing the managing their projects

- Engineering Journal
- Engineering Process Diagram
- Team Building Overview
- Understanding the Problem Flowchart
- Brainstorming Graphic Organizer
- Planning Your Time Graphic Organizer
- Design Review Graphic Organizer
- Organizational Matrix Ideas Graphic Organizer
- Recording Progress Graphic Organizer
- Gantt Chart
- PERT Chart
- Preparing for a Competition Sheet

ASSESMENT RUBRICS:

These rubrics are designed to help educators evaluate learning and assess student aptitude across a range of categories.

- Writing Criteria Rubric
- Presentation Rubric
- Work Habits Rubric
- Work Place Competencies Rubric
- Proposal Assessment Rubric
- Engineering Journal Rubric
- Robotics Exploration Rubric
- Internal Design Reviews Rubric
- External Design Reviews Rubric

ASSESMENT COMPONENTS:

Assessment Type	Category	Details	Weighting
Formative	**Observation of skills** Completion of unit modules, Practical applications	Rubric feedback, quizzes, observations, teacher conferences, journal, module questions, completion of assigned tasks	
Summative	**Mastery of skills** Challenges	1. Summative unit challenges = 70% 2. Final course challenge = 30%	100%
		TOTAL	**100%**

LEARNING RESOURCES:

Given the nature of technology, the course does not require a textbook and the resources supplied by Carnegie Mellon University are sufficient.

- NXT and TETRIX robotic kits
- NXT-G 2.0 and ROBOTC Software (school site license)
- PC Computers (laptops preferred)
- 3'x7' tables
- Storage area for lab equipment
- Adequate electrical outlets
- Access to wireless network
- LCD projector and printer

A. Curriculum:

Carnegie Mellon University: Robotics Academy
National Robotics Engineering Center
(w) education.rec.ri.cmu.edu

B. Resource / Supplier:

Spectrum Nasco Education Supplies Limited (Canada)
(w) spectrumed.com

ADDITIONAL COURSE INFORMATION:

Thanks to technology, teaching robotics has become more affordable for schools. However, schools will need to have adequate equipment and access to computers to make the course run more smoothly. Also, students will have an option to enter several regional robotics challenges if they are interested.

From: David Ennis — January 12, 2010 4:52:26 PM

Subject: Re: Fwd: Robotics Course for Review

To: **Karma Rustad**

Cc: Shelley Wilcox

Hi, Karma,

Both reviews have been completed and highly recommended. I am not able to extract them out of the district website at this time however Shelley has instructions and will be sending them to me. At that point I'll get the files to you as PDF's that you can print if necessary.

Cheers.

Dave

Karma Rustad writes:
Hope you get this!

****
Karma Rustad
K-12 Helping Teacher
Special Projects

----- **Original Message** -----

Hi David,

Please find attached a copy of the Robotics course. Below is the URL sent for reference by Dereck.

http://www.education.rec.ri.cmu.edu/content/lego/curriculum/rc_tx_index.htm

A HUGE THANK YOU for dealing this promptly.

****
Karma Rustad
K-12 Helping Teacher
Special Projects

--
David Ennis
District Helping Teacher